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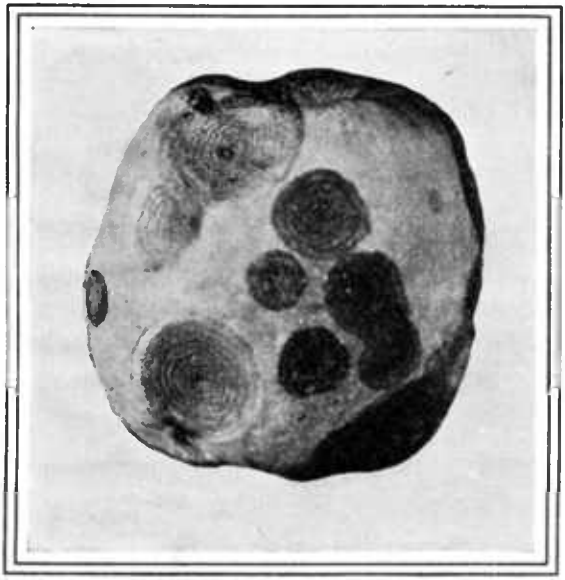
APPLE BITTER ROT AND ITS CONTROL



APPLE BITTER ROT is a serious disease in the southern apple-growing sections of the United States.

Hot weather, particularly if moist, favors the development of the disease, which is disseminated largely by rain and insects.

Different varieties of apples show varying degrees of susceptibility. In new plantings, the more resistant varieties, if otherwise desirable, should be used.

The fungus which causes the disease lives through the winter mainly in mummied fruits and in bitter rot and other cankers.

Under ordinary conditions and in the average orchard, spraying with bordeaux mixture will control the disease. Applications of the spray should be made about June 15, July 1, July 15 to 20, and August 1 to 5.

In orchards, especially those of the Middle West, in which the disease has been severe through a term of years or has not proved amenable to spraying, the overwintering sources of infection should be removed.

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APPLE BITTER ROT AND ITS CONTROL

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CONTENTS

DESTRUCTIVENESS OF APPLE BITTER ROT

BITTER ROT OF APPLES (caused by the fungus *Glomerella Cingulata* (Ston.) Sauld. and Schrenk) has long been recognized by orchardists of the southern United States as a disease of great destructiveness, especially in warm, moist seasons, and as one which it is more than ordinarily difficult to control.

In seasons when the rainfall is excessive and the temperature is uniformly high, orchards in which sources of infection are present may lose the entire crop because of bitter rot. In occasional orchards the sources of infection are so abundant that only a few days of moist, hot weather will bring about the total destruction of the crop. Generally the disease is not very destructive in cool seasons, even though plenty of moisture be present.

The disease may appear from about the middle of June until the early part of September, i. e., at any time during the warmer part of the season. Most commonly, few infected apples are to be found until after the first of July, but the grower should not take the chance of waiting for the appearance of the disease before inaugurating control measures.

Owing to the unevenness of outbreaks of the disease and the part which weather conditions play, it is impossible even to approximate the annual financial loss occasioned by bitter rot. To the grower, the money loss is increased by the fact that after he has spent time and money in preventing damage by the codling moth, and perhaps by scab or blotch, bitter rot may appear on previously clean, smooth fruits well on their way to maturity and eventually destroy them.

Typically, bitter rot is a disease of southern apple-growing sections, being of little importance where it is occasionally found in the North. It is a very serious disease in Maryland, Virginia, West Virginia, southern Indiana, southern Missouri, and to the southward of those States. It reaches its highest point of destructiveness, however, in the more western of the sections mentioned above, being especially serious in Arkansas, southern Missouri, and southern Illinois.

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DESCRIPTION

The first appearance of the disease is indicated by the presence of small light-brown, sometimes almost colorless, spots or blisterlike places just beneath the skin of the apple. Under favorable conditions and where only a few are on an apple these infected areas rapidly increase in size, often attaining a diameter of an inch in 4 or 5 days. Beneath these spots are the rotted tissues of the flesh, which extend through to the core, the rotted portion being in the shape of a cone, the base of which is at the surface of the apple and the apex at the core. The rotted flesh often, though not always, has a bitter taste. At first it is watery, in which respect it differs markedly from black rot (due to *Physalospora obtusa* (Sch.) Cooke), the only other rot with which bitter rot is likely to be confused. Later, the rotted portion may increase in size until the entire apple is involved, or it may fail to develop further and become so thoroughly dried that nothing is left but a cone-shaped cavity covered by blackened, dead, papery skin.

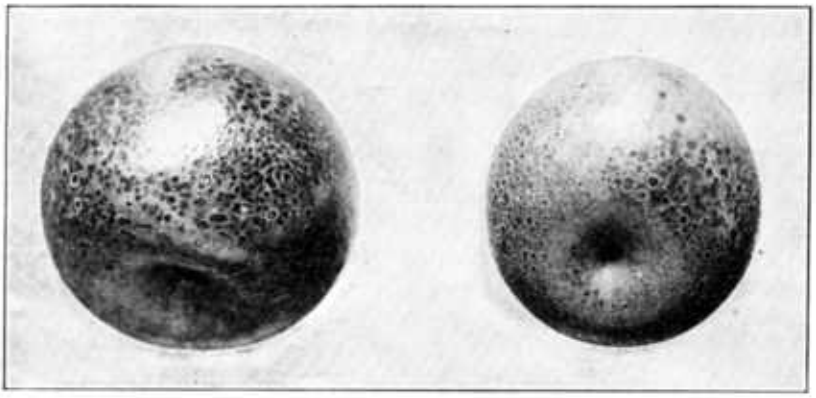

FIGURE 1.—Apples with a peppered appearance, due to many infections with bitter rot. These small blisterlike spots were caused by spores coming directly from a bitter-rot canker on a limb above.

In most cases the tissues about the rotted portion are not discolored by the disease, but yellow apples, especially those of the Yellow Newtown variety, sometimes show a purplish-red discoloration of the skin about the affected spot.

When the infections on each apple are many (and there may be as many as a thousand) usually not more than a half dozen of the spots will develop beyond an eighth of an inch in diameter. Often none will develop beyond a sixteenth of an inch in diameter, when the apples will present a peculiar peppered appearance (fig. 1).

After the spots have attained a diameter of about half an inch they become sunken because of the shrinkage of the underlying tissues. About this time, also, the acervuli, or masses of conidia, which are the reproductive bodies of the fungus, begin to appear. These occur in concentric rings and are in the nature of pustules, which upon breaking through the skin appear as rings of small beads, pink at first, later becoming dark brown or black. (See the illustration on the title page.)

CAUSE OF THE DISEASE

The fungus which causes apple bitter rot grows as an interwoven threadlike mass, or mycelium, through the tissues of the apple, between and into the cells, killing the cells themselves and breaking up the tissues. The concentric rings of pink pustules, or acervuli, which later appear on the surface of the rotted spot, are masses of the spores of the fungus, by means of which the disease is transmitted to other fruits. When weather conditions are favorable, a spore which finds lodgment on an apple may germinate and send its germ tube into the flesh, thus starting a rotten spot unless the apple has been covered previously with bordeaux mixture, in which case the germ tube dies without penetrating the skin of the apple. The fungus also produces a fruiting body, in which spores are produced in small sacs, or asci, within a tiny hard, black, more or less spherical case, or perithecium. This form of fruiting body is often referred to as the "perfect" stage of the fungus, but is not of so great importance from a disease standpoint as the pustules (acervuli).

MEANS OF DISSEMINATING BITTER ROT

It is through the agency of spores, especially those from the acervuli (imperfect stage), that the disease is transmitted to sound apples. The spore masses, or acervuli, when newly formed are pink and mucilaginous or thinly gelatinous. Later, however, upon drying, they become dark-colored and of a hard, horny consistency. Their gelatinous nature when wet and their horny consistency when dry prevent their dissemination by wind, but raindrops can spatter them about, especially upon the fruit located below them. Excessive moisture also can cause the spore masses to trickle or drip down from infected fruits and alight upon sound ones. Birds probably play some part in the dissemination of spores, but a much more important role is played by insects, more especially flies. It has been demonstrated repeatedly that flies alighting upon infected apples come in contact with the mucilaginous spore masses, some of which adhering to them may be carried to and deposited upon sound fruit.

RELATIVE SUSCEPTIBILITY OF APPLE VARIETIES

Most varieties of apples are susceptible to bitter rot, at least to some extent, but they differ considerably in this respect, as table 1 shows. The susceptibility or resistance of a given variety will often vary considerably according to the section of the country in which it is grown and its location with respect to highly susceptible or highly resistant varieties. Weather conditions also constitute an important factor. During prolonged periods of hot, moist weather, the fungus is able to attack successfully varieties which are normally rather resistant.

TABLE 1.—*Relative susceptibility of apple varieties to bitter rot of the fruit*

Very susceptible	Moderately susceptible	Rather resistant	Resistant
Corfu	Ben Davis	Arkansas	Akin
Fallawater	Gano	Baldwin	Arkansas Black
Gibbs	Golden Delicious	Delicious	Lankford
Givens	Grimes Golden	Maiden Blush	Ralls
Highfill	Jonathan	Rome Beauty	Salome
Huntsman	Limbertwig	Stayman Winesap	Winesap
Lansingburg	Missouri Pippin	York Imperial	
Smokehouse	Nero		
Willowtwig	Northern Spy		
Yellow Newtown	Northwestern Greening		
	Oliver Red		
	Winter Paradise		
	Pilot		
	Smith Cider		
	Stark		
	Winter Queen		
	York Stripe		

When new plantings of the apple are made in sections in which bitter rot is prevalent, preference should be given to the more resistant varieties, provided they are otherwise desirable.

SOURCES OF INFECTION

Knowledge as to the places in which the causal fungus is able to live through the dormant season and to develop and reinfect the fruit during the following summer is of importance in determining measures for the control of the disease. If it were possible to eliminate all such places, control would be obtained without further effort.

The fungus causing apple bitter rot usually lives through the winter in mummied apples, in bitter-rot cankers or cankers in which this fungus is the causal organism, and in cankers caused by other agencies.

Mummied fruits constitute the most common source of infection throughout the bitter-rot section of the United States. A mummied fruit is one which during the previous season has been affected with the disease and has remained on the tree or on the ground in a more or less shriveled condition. In such fruits the fungus is able to exist throughout the winter, producing spores when the hot season returns. The spores from mummies hanging in the tree are spattered by the rain upon the current season's fruits, thus infecting them with the disease (fig. 2). Infection from mummies on the ground takes place through the medium of flies or by actual contact between the mummied fruits and the apples on low-hanging limbs.

The bitter-rot canker is a common source of infection in the western part of the bitter rot section, but is rare in the eastern part. The canker (fig. 3) consists of a black sunken portion of bark, usually somewhat oval in outline, beneath which the wood is dry and dead. The dead bark and cambium adhere rather firmly to the wood, and in older cankers more or less complete cracks, or fissures, parallel to the edges of the cankers, give a zoned effect to the dead bark. Often the canker is surrounded by a layer of callus which prevents its further extension and eventually heals over the old lesion. Cankers usually are not found on branches which are less than 2 years of age. In cankers the fungus may live 1 or more

years, producing each season immense quantities of spores, which may be carried to sound fruits. The crop of a tree in which there are many bitter-rot cankers during a hot, moist season is doomed to destruction despite frequent and thorough sprayings.

The susceptibility of different varieties of the apple to this phase of the disease varies to a considerable degree. Among commercial varieties the Givens is very susceptible, while the Jonathan, Mis-

FIGURE 2.—An apple affected with bitter rot and, just above it, a mummied apple of the preceding season. Spores washed down from the mummy have infected the previously sound apple.

souri Pippin, Ben Davis, and Grimes Golden, in the order named, are moderately susceptible. The York Imperial and the Yellow Newtown are practically immune to the canker phase of the disease.

The fungus may live through the winter in cankers caused by agencies other than bitter rot and on dead branches and the tips of fruit spurs. Where the fungus exists in these places and, in addition, mummies and bitter-rot cankers are present, during seasons favorable to bitter rot any control measures that do not take into consid-

eration the elimination of sources of infection will be inefficient, if not entirely useless.

Infected fruits of the current year also are dangerous sources of infection, since from them sound apples may become infected. It is by them that the disease is spread during the growing season, after it has gained a start from spores produced in the places in which the fungus has passed the winter; therefore, in the control of the disease it is of prime importance to prevent any infections from occurring or, if they do occur, to remove, if practicable, the infected fruits, to-

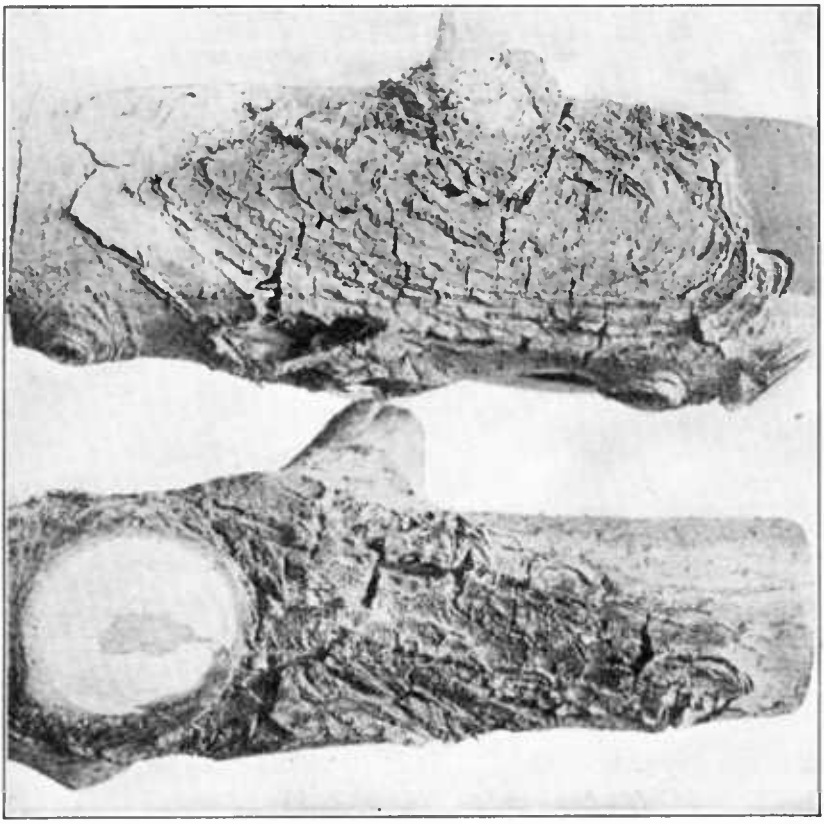

FIGURE 3.—Bitter-rot cankers which were located directly above clumps of rotted fruits. These cankers were producing spores in immense numbers.

gether with the mummies or cankers from which the infection came, before they can act as infection carriers. The fungus may infect other hosts besides the apple and sometimes occurs on apple leaves, but these are of little importance from the standpoint of disease control.

In the Eastern States mummies are usually the places where the fungus passes the winter, but in the Middle West, especially in badly infected orchards, limb cankers caused by the bitter-rot fungus and by other agencies often surpass mummies in importance.

REMEDIAL MEASURES

SPRAYING

Under ordinary conditions and in the average orchard in bitter-rot sections (one in which the disease has not annually destroyed almost the entire crop), 3 or 4 thorough sprayings with bordeaux mixture will afford adequate control. Spraying for the control of bitter rot, however, must be done with special care, and at least one application should be made before the disease appears. For complete coverage it is necessary for the spray to strike each fruit from at least two sides.

Bordeaux mixture, composed of 4 pounds of bluestone (copper sulphate) and 4 pounds of stone lime or 6 pounds of hydrated lime to 50 gallons of water, should be applied (1) about June 10 to 15, (2) about July 1, (3) about July 15 to 20, and (4) about August 1 to 5. In cool or dry seasons the intervals between applications may be increased about 1 week, and only three applications made. The complete schedule is applicable to winter apples only. Summer apples should not be sprayed later than 1 month before ripening. Apples to be eaten at home or offered for sale should be free from spray residues. It is best, if practicable, to avoid the risk of residues at picking time by not spraying late in the season. If this is not practicable, it will be necessary to wash the fruit before it is used, particularly if lead or arsenic is present in the residues at harvest time in amounts that would be dangerous to health. Directions for washing fruits to free them from spray residue may be obtained from State agricultural experiment stations and the United States Department of Agriculture.

Lime-sulphur solution, though efficient in the control of apple scab, will not control bitter rot.

REMOVAL OF SOURCES OF INFECTION

In the case of some orchards, especially many of those in the Middle West in which the disease has been very destructive for a term of years, often in spite of frequent and thorough spraying, it will be necessary to remove as many as possible of the overwintering sources of infection, besides following out the spray schedule just mentioned. In some of these orchards the disease has gained such a foothold that at the very first outbreak nearly every apple will show an average of from 50 to 100 points of infection from overwintering sources. Spraying alone under such conditions will act as a preventive to some extent but will not give adequate control. With such abundant sources of infection, control by spraying could be accomplished only by keeping the entire surface of every apple covered with bordeaux mixture throughout the infection period, which is obviously impossible. In many orchards there will be only a few trees, or perhaps a single section of the orchard, in which the disease is not amenable to control by spraying. Often from such trees the entire orchard will become infected; therefore, special attention should be given to the removal of overwintering sources of infection from them.

The best time for the removal of mummies hanging on the trees is during the dormant season, when they can be poked off with a stick or pulled off by means of a pole with a wire hook attached. If, however, care be taken at picking time to remove the infected as well as the sound fruit there will be few mummies to remove later. Those on the ground can be removed at picking time or at any time before the next summer, or if not numerous they may be turned under when spring cultivation is commenced. In many orchards, such as those planted on rocky hillsides, the removal of mummies on the ground is impracticable; however, they are not nearly so important as those hanging on the trees.

The removal of cankers and deadwood can be carried on to the best advantage in connection with the spring pruning. It is not so difficult an operation as many growers seem to think and is usually not nearly so expensive as a single application of bordeaux mixture. It should be remembered that the removal of the cankers and deadwood helps to prolong the lives of the trees and is an efficient measure in the control of other diseases, especially black rot or ring rot and leaf spot.

In most cases bitter-rot cankers as well as cankers caused by other agencies will be found on relatively small limbs, and usually they can be removed by simply sawing or cutting off the limbs.

Cankers on large limbs may be removed by means of a sharp knife or, better, a carpenter's gouge. The cut should be made well into the living bark and the margins evenly trimmed unless a callus layer has already begun to form. It is best to sterilize the cut places and tools at every operation with a mercuric-chloride solution (1 to 1,000 strength). Mercuric chloride is procurable in tablet form at all drug stores, and directions are given on the bottles for making a 1 to 1,000 solution. After a few days the exposed wood should be coated with a paint composed of white lead and linseed oil, or a mixture of one-third creosote and two-thirds coal tar of the cheaper grades may be applied immediately. If the mixture of creosote and coal tar is used it is not necessary to treat the wound with the mercuric-chloride solution.

The removal of all infected fruit during the growing season is of great importance in preventing the spread of apple bitter rot, especially when the first application of spray has been made too late or when it appears that the disease is about to gain a foothold early in the season. Of course, this is only practicable at the time the disease first appears and when comparatively few fruits have rotted. At that time it is usually practicable to remove the few infected fruits and to locate and remove many of the overwintering sources of infection overlooked during the dormant season, since the fruits below such sources are the first to be infected. Later, of course, such clumps of infected fruits will not serve as indicators of the location of overwintering sources of bitter rot, since the infected fruits themselves serve to spread the disease and thus become sources of infection. When the removal of the first infected fruits and corresponding overwintering sources of infection is practiced, a thorough application of bordeaux mixture should be made directly afterwards. In this way the writers have checked effectually at a nominal cost threatening outbreaks of this disease, in one case the expense of so treating three

hundred 20-year-old trees being only $10 in addition to the usual cost of spraying.

All the methods of control herein outlined have been used successfully by the writers and by growers. The sanitation methods recommended are especially adapted to and practicable in the apple-growing sections of northern Arkansas, southern Missouri, and southern Illinois. In 3-years' time the writers, with the grower's aid, nearly eradicated the disease from one of the worst infested orchards in the United States and had it under control during the very first year.

DIRECTIONS FOR MAKING BORDEAUX MIXTURE

Bordeaux mixture for use in bitter-rot control should contain ordinarily 4 pounds of bluestone (copper sulphate) and 4 pounds of quicklime to each 50 gallons of water. In orchards in which the disease has not been very serious in previous years, the quantity of bluestone may be reduced to 3 pounds. If the lime used is of poor quality and does not slake readily, 5 or 6 pounds of lime should be used.

The directions here given are for quicklime, or stone lime. If hydrated lime is used the quantity should be increased one-third or more. As hydrated lime is already slaked, it is ready for the required quantity of water to be added to it, as set forth in these directions.

To make a single barrel (50 gallons) of bordeaux mixture, dissolve the bluestone in 25 gallons of water, and in a separate barrel slake the lime and dilute it to 25 gallons. Then pour the contents of the two barrels simultaneously through a strainer into the spray tank.

If large quantities are to be used, a stock solution of the bluestone and a stock milk of lime should be prepared in order to save time.

A stock solution of bluestone may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or a box with perforations in the bottom and sides) containing 50 pounds of bluestone in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the bluestone will have entirely dissolved, when the sack or box should be removed and enough water added to fill the barrel. Time may be saved by using hot water, in which the bluestone will dissolve in a few minutes. After being stirred, the solution is ready for use.

A stock milk of lime may be prepared by slaking 50 pounds of stone lime in a barrel or other vessel and finally adding water to make 50 gallons. In slaking the lime sufficient water should be used to prevent burning but not enough to "drown" it. The water should be added a little at a time and the mixture stirred to the bottom until the slaking is nearly completed. Sufficient water should then be added to leave a paste when the slaking is finished. Water to make the 50 gallons may then be added when desired.

Bordeaux mixture is easily made if a power sprayer with a good agitator is at hand. Fill the tank with water until there is room for only the required quantities of the stock fluids. Then, starting

the engine (and accordingly the agitator), put in the stock bluestone solution and slowly add the stock milk of lime. For example, if the tank holds 200 gallons, fill with water to about the 160-gallon mark and then, starting the engine, slowly add the 16 gallons of stock bluestone solution if the 4:4:50 formula is to be followed and afterwards the 16 gallons of stock milk of lime. Allow the engine to run for a few minutes after both fluids have been added. Add more water, if necessary, to fill the tank. By this method an elevated platform is not needed, especially if an efficient mechanical tank filler is at hand.

For those not possessing power sprayers the following directions are given:

Place the necessary quantities of the stock copper-sulphate solution and the stock milk of lime in separate elevated dilution tanks, each of which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and, according to the 4:4:50 formula, 16 pounds of copper sulphate (16 gallons of the stock solution) and 16 pounds of lime (16 gallons of stock milk of lime) would be required. To each dilution tank add water to make nearly 100 gallons (nearly half the total quantity of spray), and, after stirring, allow the diluted ingredients to run simultaneously through a strainer into the spray tank from separate hoses or troughs attached to faucets near the bottom of each dilution tank.

The so-called "instant" bordeaux mixture is easily made if a power sprayer with a good agitator is at hand. In the preparation of this mixture a powdered bluestone that dissolves quickly in water is used. It may be dissolved while the tank is being filled by placing the required quantity in a cloth sack suspended within the tank so that the inflowing water will wash through it. This may be accomplished by inserting the end of the intake hose in the open end of the sack. When the tank is about three-fourths full and all the bluestone is dissolved, the engine should be started, to operate the agitator. Then the milk of lime, made from either stone lime or hydrated lime, should be added slowly while the filling of the tank is completed. Hydrated lime in a dry state is sometimes used, but a better product is made if it is first mixed with enough water to make it pour easily and then allowed to stand for a few hours before being used.

Only the quantity which can be used immediately should be prepared, as bordeaux mixture deteriorates on standing. Granulated sugar at the rate of 2 teaspoonfuls for each 50 gallons dissolved in a little water and added to the mixture has been recommended for retarding the rate of deterioration.

When arsenicals or other insecticides are to be used with bordeaux mixture and are mixed with water before being added to the spray tank, allowance should be made for these by leaving out the corresponding quantity of water from the quantities specified.

There are on the market a number of commercial bordeaux mixtures which are ready for use when mixed with water. These are usually sold under proprietary trade names. Growers interested in these preparations should consult United States Department of Agriculture Farmers' Bulletin No. 994, entitled "Commercial Bordeaux Mixtures: How to Calculate their Values."

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